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By-catches of Greenland Halibut and Redfish in the Shrimp Fishery at West Greenland

by

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Abstract.

By-catches of Greenland halibut and redfish were recorded in research trawl hauls for shrimp made by the research vessel "Adolf Jensen" 1968-87 and in trawlings by the commercial trawler "Sisimiut" in 1976-77. Based on these data and total landings of shrimp in 1986, total by-catch in the shrimp fishery in Subarea 1 south of 71oN latitude is estimated as 58 mill. specimens of Greenland halibut and 111 mill. specimens of redfish. Highest number of Greenland halibut per hour of trawling occurred most northerly. Lengths ranged from 5 to 86 cm showing a northern distribution of the small fish below 15 cm. Number of redfish per hour of trawling did not differ markedly between the areas. Lengths ranged from 5 cm to 49 cm also showing a northern distribution of the smallest fish. Weight percent of by-catch of Greenland halibut and redfish in the research hauls were estimated to 20% and 32% respectively for the area investigated, which is considerably higher than the by-catches reported by the commercial fleet itself.

Introduction.

The increasing fishery for shrimp at West Greenland reached a level of about 60.000 tons in 1986. The recent increase has occurred on the traditional offshore fishing grounds south of 71°N as well as on the newly exploited areas north of 71oN. This paper gives an estimate of by-catch in 1986 of Greenland halibut (Reinhardtius hippoglossoides Walb.) and redfish (Sebastes ssp.) in the fishery for shrimp in Subarea 1 south of 71°N. No by-catch data is available for the fishery north of 71oN. By-catches of the commercial trawler "Sisimiut" during 1976-77 are compared to research trawl hauls for shrimp by the research vessel "Adolf Jensen" during 1968-87 in order to use the latter for the by-catch calculation. Comparisons are made of these by-catch estimates with those stated by commercial Greenland shrimp trawlers as well as with those obtained from other investigations in the areas.

Material and Methods.

Area of investigation.

The West Greenland area has been divided into 5 strata as shown in Fig.1. The break-down has been made with regard to the location of the shrimp fishing grounds as shown by Carlsson and Smidt (1978) and to management areas used by Greenland authorities in regulation of the shrimp fishery.

Stratum 1 : Disko Bay
north of 68°00'N lat., east of 53°45'W long.

Stratum 2 : North of St. Hellefisk Bank
north of 68°00'N lat., west of 53°45'W long.

Stratum 3 : West of St. Hellefisk Bank
north of 66°15'N lat., south of 68°00'N lat.

Stratum 4 : South of St. Hellefisk Bank
north of 64°15'N lat , south of 66°15'N lat.

Stratum 5 : Southwest Greenland
south of 64°15'N lat.

By-catch data.

Catch data from a trawl survey carried out in stratum 2 and 3 in July 1976 and from commercial fishery in same strata in October 1976 and June 1977 were analysed. The trawlings were made by the commercial stern trawler "Sisimiut" kindly placed at the disposal of the Greenland Fisheries Research Institute by the Royal Greenland Trade Department. Only hauls with mean depth in the interval 180-450 m were included in the analysis. The total number of hauls were 101. Mesh size in codend was 21 mm (barlength). Further information on trawl parameters are given by Horsted (1978), who estimated the shrimp biomass based on catch data in July 1976. The catch of shrimp was recorded in units of boxes, each containing about 30 kg. From the total unsorted catch in each haul 30-60 kg was sampled and the weight of shrimp together with the number and weight of Greenland halibut and redfish were recorded. In most cases length measurements were taken too, as total length to nearest centimeter below.

During the period 1968-87 the Greenland Fisheries Research Institute carried out a considerable number of research hauls for shrimp by the research vessel "Adolf Jensen". Among these data 426 hauls have been selected for further analysis according to several criteria :

1) Only hauls from the shrimp fishing grounds shown by Carlsson and Smidt (1978) or in the immediate vicinity of these have been used (Fig.1).
2) The period from January to October was selected to avoid bias from few hauls with large catches of newly settled Greenland halibut.
3) Only hauls on mean depth in the interval 180-450 m were included.

Mesh sizes in codend varied between 18 and 21 mm (barlength) The catch of shrimp and by-catches of fish were recorded and in most cases length measurements of redfish and Greenland halibut were made. Redfish was not identified to species level. Fish were measured as total length to nearest cm below. Samples of small Greenland halibut and redfish were frozen and brought to the laboratory in Copenhagen where the specimens were measured as total length to the centimeter below and weighed to the nearest gram after thawing.

By-catch estimation.

The number of fish per kg shrimp is calculated as the total number of fish caught in the stratum divided with the total catch of shrimp.

On the basis of total catch estimates of shrimp per strata in 1986 and number of fish per kg shrimp and mean weight of Greenland halibut and redfish, by-catches are estimated for each stratum and raised to total by-catch by stratum. The mean weight of Greenland halibut and redfish was calculated for each stratum by multiplying the mean weight for each centimeter group with the abundance in length distributions.

In the estimation it is assumed that within the strata, shrimp and by-catch species both have a uniform distribution equal in range.

Results.

The shrimp fishery and by-catches in the fishery.

The nominal catches of shrimp in Subarea 1, 1977-86 are shown in Table 1. Catches increased during this period, and in 1986 the total catch was 60,134 tons. Because no research data exists of by-catches in the offshore area north of 71oN, this area is excluded from these analyses. Likewise, the only inshore area included in the analyses is the Disko Bay. Total catches of shrimp in 1986 by strata have been estimated. Stratum 1 (Disko Bay) is the most important inshore fishing ground and has an estimated catch of 6000 tons (Carlsson pers. comm.). The total catch in strata 2-5 has been broken down according to the catch reports to Greenland authorities by all vessels above 80 GRT, which in 1986 accounted for 87% of the total offshore catch south of 71oN. The following figures were obtained:

stratum 1	stratum 2	stratum 3	stratum 4	stratum 5
6000 tons	12000 tons	15500 tons	10000 tons	4500 tons

The only data of by-catches in the shrimp fishery presently available are logbook reports by trawlers owned by the Greenland Home Rule authorities (earlier the Royal Greenland Trade Department) (Table 2). Shrimp catches by these trawlers in the last three years accounts for about 30% of the total offshore catch south of 71°N. Only lately Greenland halibut has been reported as by-catch having a 1986 level on 0.2% by weight in relation to total shrimp catch with the highest amount in stratum 2. By-catches of redfish have been reported for the entire period from all strata. The by-catch level of redfish in relation to

total shrimp catch was between 14.8% and 25.4% in 1977-79, but in the last six years only between 1.3% and 2.5%, mainly because of a drastic decline of the by-catches in strata 2 and 3 (NAFO 1983).

"Sisimiut"'s hauls for shrimp.

Table 3 shows the mean catch of shrimp per hour of trawling and the mean number of Greenland halibut and redfish per hour of trawling together with the number of fish per kg shrimp by stratum.

Mean cpue of shrimp is highest in stratum 3 with 554 kg per hour of trawling in comparison with 193 kg for stratum 2.

For Greenland halibut both mean cpue and number of fish per kg shrimp are higher in stratum 2 than in stratum 3. Fig. 2 shows length distributions of Greenland halibut from the two strata. It appears that small Greenland halibut are predominating in stratum 2, peaking at both 11 cm and 18 cm, while these peaks are not so marked in stratum 3, where lengths are distributed within a broader range.

Mean cpue of redfish is considerably higher in stratum 3 than in stratum 2 with values of 6690 and 1636 specimens per hour of trawling respectively. Likewise number of redfish per kg shrimp is higher in stratum 3 at 13.49 specimens in comparison with 6.89 specimens per kg shrimp in stratum 2. Length distributions of redfish in the two strata are rather similar, within the range 6 - 21 cm (Fig. 3).

"Adolf Jensen"'s research hauls for shrimp.

The mean catch of shrimp per hour of trawling, the mean number of Greenland halibut and redfish per hour of trawling and the number of fish per kg shrimp are shown in Table 4 for "Adolf Jensen"'s trawl survey.

For strata 2 and 3 are given catch data of shrimp and by-catches for the two selected periods 1976-77 and 1981-87, the former in order to compare results with the hauls by "Sisimiut" and the latter to exclude the period before 1981 with high by-catches of redfish. The low number of hauls in stratum 1,4 and 5 in the selected periods do not allow any similar estimation for these strata.

Mean cpue of shrimp are very similar in all strata, 112-228 kg per hour of trawling with the highest value in stratum 3.

There are major differences in mean cpue of Greenland halibut between strata (Table 4). In the two most northerly strata 1 and 2 the mean cpue are considerably higher than in the southern strata (3-5). Mean cpue of Greenland halibut in stratum 2 are a bit higher than mean cpue from "Sisimiut"'s data, while the value in stratum 3 are somewhat lower. However, in both surveys mean cpue is higher in stratum 2 than in stratum 3. Fig. 4 shows length distributions in each stratum and it appears that small Greenland halibut are predominating in strata 1 and 2, while this is not so evident in strata 3,4 and 5. The distribution in stratum 3 is very

alike the distribution obtained from "Sisimiut"'s hauls. In stratum 2 both show a peak at 11 cm, but a peak at 18 cm also occurs in "Sisimiut"'s hauls. The number of Greenland halibut per kg shrimp are higher in strata 1-2 (4.25 and 2.33 respectively) than in stratum 3 and 5 (between 0.13-.25). For stratum 2 and 3 there do not seems to be considerable differences in mean number per hour of trawling neither of fish per kg shrimp between the periods 1976-77 and 1981-87. Compared with "Sisimiut"'s hauls, the number of Greenland halibut per kg shrimp is higher in stratum 2 in this survey (2.98 vs. 1.07), while the opposite is the case for stratum 3 (0.12 vs. 0.24).

The mean number of redfish varied from 313 specimens per hour of trawling in stratum 4 to 1596 in stratum 3 (Table 4). There is no trend in the abundance. For strata 2 and 3 in 1976-77, mean cpue is about half that of "Sisimiut"'s hauls. From the length distributions (Fig. 5) it appears that in strata 1-3 redfish from 6 cm to about 18 cm are predominating in the catch, very similar to the distributions obtained from "Sisimiut"'s hauls in stratum 2 and 3, while in strata 4-5 length distributions are more broad with fish lengths ranging from 6 cm to 45 cm. Furthermore the length distribution in strata 4-5 tends to be bimodal. The number of redfish per kg shrimp is highest in stratum 3 (7.30 per kg shrimp), while there is no significant difference between the other strata (2.62 - 3.36 per kg shrimp). However, there are major differences between the periods 1976-77 and 1981-87 for stratum 2 and especially for stratum 3 in both mean cpue of redfish and number of fish per kg shrimp with the highest values in the period 1976-77. For both strata number of redfish per kg shrimp are somewhat lower than in the "Sisimiut" fishery.

Estimates of by-catches.

"Adolf Jensen"'s trawlings were used for by-catch estimates as these trawlings covers an extensive period and by-catches are in reasonable accordance with those of the commercial trawler "Sisimiut" for the period 1976-77.

For Greenland halibut strata 1 and 2 account for nearly all the by-catch estimated (85% by weight). Total by-catch is estimated to be 57 mill. specimens or 9,507 tons (Table 5).

Because of the decline in by-catches of redfish in the late 1970'ies by-catch estimates are based on hauls in 1981-87 for strata 2 and 3 only. For strata 1,4 and 5 it is not possible to use a similar procedure because the low number of hauls in 1981-87 does not allow any estimation of cpue values for which reason by-catch estimates from strata 1,4 and 5 are based on data from the whole period 1968-87. By-catch of redfish in numbers are rather equal except for stratum 5. However, by weight stratum 4 and 5 accounts for 84% because of the high mean weight of specimens in these southern areas. Total by-catch is estimated to be 111 mill. specimens or 15,584 tons.

Discussion.

The trend of estimated by-catch of redfish from 1976-77 to 1981-87

as shown in table 4 follows the reported decline in by-catch of redfish in 1979-81 by Greenland commercial trawlers. The decline is also noted by local fishermen. Changes in by-catch of Greenland halibut do not seem to have occurred.

Therefore it seems reasonable to estimate the by-catch of redfish on the basis of 1981-87 data from "Adolf Jensen", although this is possible only for strata 2 and 3.

The decline of by-catch of redfish is mainly observed in Division 1B (NAFO 1983), which in this investigation is a part of strata 2 and 3. Therefore using the entire period 1968-87 for the calculation of by-catches of redfish in strata 1,4 and 5 is considered to result in only a minor bias on the estimating.

Total by-catch of Greenland halibut in strata 1 - 5 is estimated to 58 mill. specimens corresponding to about 9,500 tons for 1986. The northern areas Disko Bay (stratum 1) and North of Store Hellefisk Bank (stratum 2) account for catches with far the highest numbers of Greenland halibut per kg shrimp. Also in these areas small Greenland halibut are most abundant with respectively 70% and 80% below 20 cm compared to the southern areas (strata 3-5) with respectively 48%, 64% and 40% below 20 cm. This geographical distribution is in accordance with Smidt (1969a).

The total by-catch estimate of redfish in strata 1 - 5 is 111 mill. specimens corresponding to about 16,000 tons. Since data from the period before 1980 for strata 4 and 5 in by-catch calculations are included in the estimation, the 111 mill. specimens are considered to be an over-estimate of recent by-catches. However, comparison of by-catch data in 1976-77 between "Adolf Jensen" and "Sisimiut", suggest that the estimate is to low. By-catch in numbers per kg shrimp seems to be rather similar in the five strata in "Adolf Jensen" hauls. When analysing by-catch in terms of weight per kg shrimp, the southernmost strata (4 and 5) account for far the highest by-catch (83%). This is because redfish in the two southernmost strata are longer (6 - 45 cm) than in the northern strata (6 - 18 cm).

Percentages by weight of by-catch of Greenland halibut and redfish in the area of investigation for the hauls made by "Adolf Jensen" are 20% and 33%, respectively. The corresponding values for the commercial trawlers in 1986 are far below at 0.2% and 2.5% respectively (Table 2).

The trawl used by "Sisimiut" has a higher net opening than that used by "Adolf Jensen". A comparison of mean number of Greenland halibut and redfish per hour trawling in strata 2 and 3 in 1976-77 for "Adolf Jensen" and "Sisimiut" does not show any clear tendencies regarding catch rate of Greenland Halibut, while cpue of redfish is obviously greater for "Sisimiut" than for "Adolf Jensen" (Tables 4 and 5). This could be because small Greenland halibut are more demersal than redfish.

Furthermore research hauls for shrimp at fixed stations may not be representative of a commercial fishery continuously shifting grounds for getting high catch rates.

Norwegian investigations on the shrimp stocks off Store Hellefiske Bank (stratum 3) were carried out in 1982-83 (Jakobsen and Torheim

1983, Smedstad and Torheim 1984). By-catch of Greenland halibut and redfish in 1982-83 amounted to 0.04 and 0.03 Greenland halibut per kg shrimp and 0.41 and 0.55 redfish per kg shrimp, respectively. In 1984 Norwegian investigations were carried out south of Store Hellefisk Bank (stratum 4). By-catch amounted to 0.005 Greenland halibut per kg shrimp and 0.13 redfish per kg shrimp (Smedstad and Torheim, 1985). These values are far below those of "Adolf Jensen", although the difference between stratum 3 and stratum 4 supports the tendency obtained by "Adolf Jensen". The Norwegian investigations were carried out on a commercial vessel on which researchers recorded the by-catch. This might cause the difference between the Norwegian and the Danish results. Further gear selection might have some effect.

Smidt (1969b) gave an estimate of 15 mill. small Greenland halibut as by-catch in the Disko Bay (stratum 1) shrimp fishery in 1965. This estimate is in accordance with the present estimate (25.5 mill.), taking into account that the fishery in 1965 amounted to about 2000 tons shrimp below the present level.

The estimates obtained for the investigated area for 1986 of 58 mill. Greenland halibut and 111 mill. redfish can very well be biassed and must be considered as rough estimates giving orders of magnitude.

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Table 1. Nominal catches of shrimp in Subarea 1, 1977-86 (from NAFO 1986).

Area / Year	Offshore (S of 71°N)	Offshore (N of 71°N)	Inshore
1977	33.843	-	7.800
1978	26.747	-	7.600
1979	25.958	-	7.500
1980	35.778	-	7.500
1981	32.016	-	7.500
1982	35.015	-	7.500
1983	33.854	-	7.500
1984	33.741	-	7.500
1985	40.565	4.349	7.500
1986	41.589	11.045	7.500

Table 2. Catches of shrimp (tons) and by-catches (tons) by strata of trawlers owned by the Greenland Home Rule authorities (no data from stratum 1).

Year		1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
Stratum											
2	Greenland halibut				1.6				0.2	6.8	15.4
	Redfishes	1.8	340.6	358.5	331.3	71.7	55.1	50.0	105.7	60.0	138.5
	Unknown		0.4							8.1	0.9
	Shrimp catch	112.5	1880.1	3126.3	6525.3	4534.1	4957.0	3912.4	2762.5	3619.8	4191.7
3	Greenland halibut									0.2	4.0
	Redfishes	894.4	935.2	633.3	99.3	54.4	23.7	26.4	101.5	59.3	110.7
	Unknown		8.8							19.3	0.1
	Shrimp catch	5061.7	3147.2	3786.2	1159.4	4107.8	1518.5	1713.0	3820.9	3893.5	4597.1
4	Greenland halibut			1.3	0.4						2.0
	Redfishes	2.8	16.9	41.5	40.5	18.1	19.5	54.1	64.5	31.2	50.5
	Unknown		17.0							8.3	0.4
	Shrimp catch	338.5	65.0	89.2	566.0	1116.1	1147.8	1300.8	3542.9	3312.2	2469.8
5	Greenland halibut				0.4						0.9
	Redfish		6.4	0.2	0.2			1.4	1.6	8.5	15.3
	Unknown									4.3	
	Shrimp catch	13.1	24.4	1.4	49.1	10.4	5.6	64.4	441.2	1066.2	1097.6
Total	Greenland halibut			1.3	2.4				0.2	7.0	22.3
	Redfishes	899.0	1300.1	1033.5	471.3	144.2	98.2	131.9	273.3	159.0	315.0
	Unknown		29.2							40.0	1.4
	Shrimp catch	5525.8	5117.0	7003.1	8299.8	9768.4	7628.9	6990.6	10567.5	11891.7	12356.2
Greenland halibut in % of total shrimp catch				<0.1	<0.1				<0.1	<0.1	0.2
Redfishes in % of total shrimp catch		16.3%	25.4%	14.8%	5.7%	1.5	1.3	1.9	2.6	1.3	2.5

Table 3. Catch of shrimp and by-catches of Greenland halibut and redfish by strata in "Sisimiut"'s fishery in 1976-77.

	Stratum 2	Stratum 3
no of hauls	22	79
Shrimp		
mean weight (kg)/hour trawling	193	554
Greenland halibut		
mean number/hour trawling	249	127
no of fish/kg shrimp	1.07	0.24
Redfish		
mean number/hour trawling	1636	6690
no of fish/kg shrimp	6.89	13.49

Table 4. Catch of shrimp and by-catches of Greenland halibut and redfish by strata in "Adolf Jensen"'s research hauls for shrimp. Figures for the periods 1976-66 and 1981-87 are given only for strata 2 and 3 (see text).

	Period	Stratum 1	2	3	4	5
no of hauls	1968-87	97	102	71	21	135
	1976-77		5	26		
	1981-87		72	36		
Shrimp						
mean weight (kg)/hour trawling	1968-87	161	132	228	112	114
	1976-77		121	583		
	1981-87		116	150		
Greenland halibut						
mean number/hour trawling	1968-87	676	288	28	16	34
	1976-77		362	47		
	1981-87		189	18		
no of fish/kg shrimp	1968-87	4.25	2.33	0.13	0.13	0.25
	1976-77		2.98	0.12		
	1981-87		1.64	0.12		
Redfish						
mean number/hour trawling	1968-87	617	420	1596	313	618
	1976-77		672	3551		
	1981-87		407	267		
no of fish/kg shrimp	1968-87	3.36	3.31	7.30	2.62	2.98
	1976-77		5.54	9.23		
	1981-87		3.52	1.77		

Table 5. Estimates of by-catches of Greenland halibut and redfish in total shrimp fishery at West Greenland, based on "Adolf Jensen"'s research hauls.

		Stratum					
		1	2	3	4	5	Total
Greenland halibut	('000)	25500	27960	2015	1300	1125	57.900
" "	(tons)	2629	5508	388	270	776	9.507
Redfish	('000)	20160	42240*	21240*	26200	1341	111.181
"	(tons)	690	883*	909*	9110	3992	15.584

*) estimates are based on research hauls in the period 1981-1987.

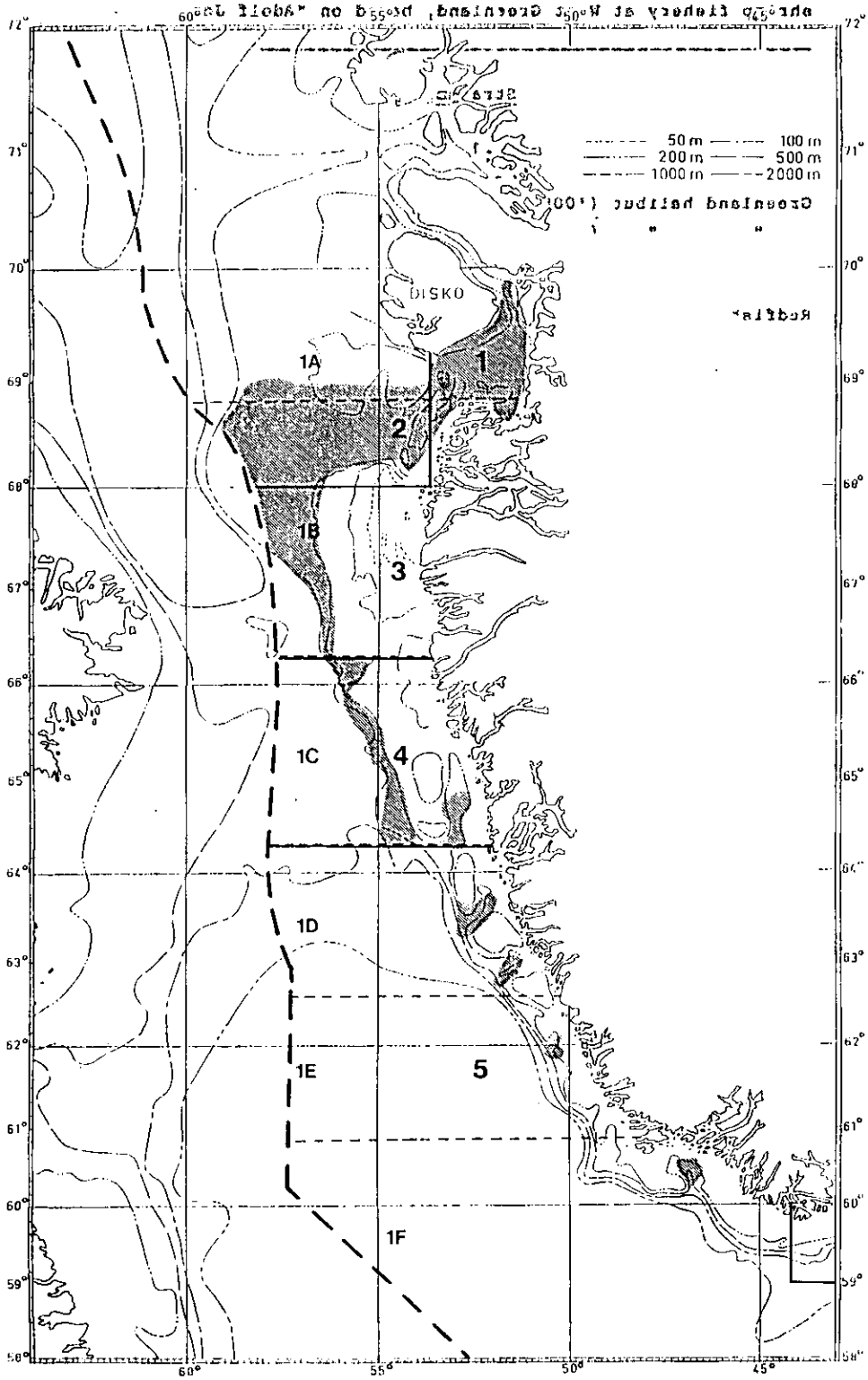

Fig. 1. The area covered by "Adolf Jensen"'s trawl surveys (hatched area) and the stratification of the area (solid lines) marked by figures 1-5. NAFO Divisions are shown by dashed lines.

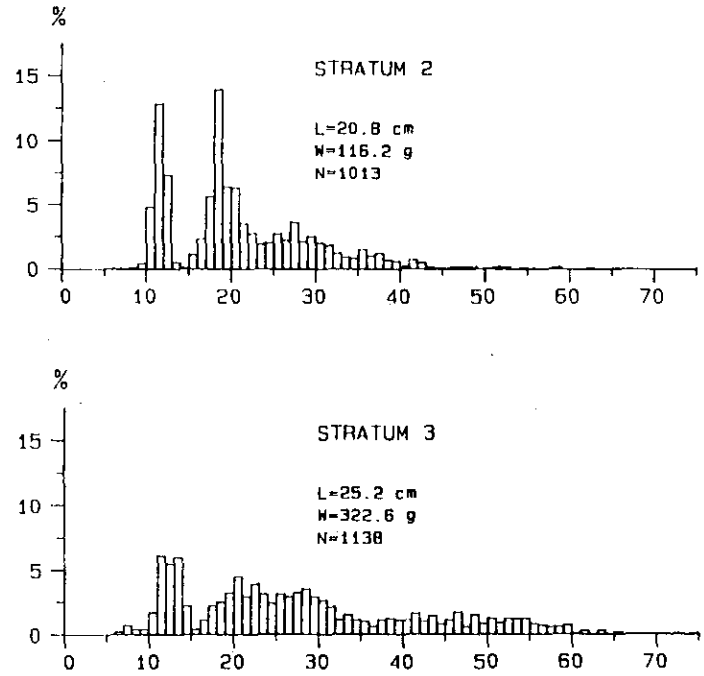

Fig. 2. Length distribution of Greenland halibut from "Sisimiut"'s trawlings in 1976-77 (L: mean length, W: mean weight, N: number of fish).

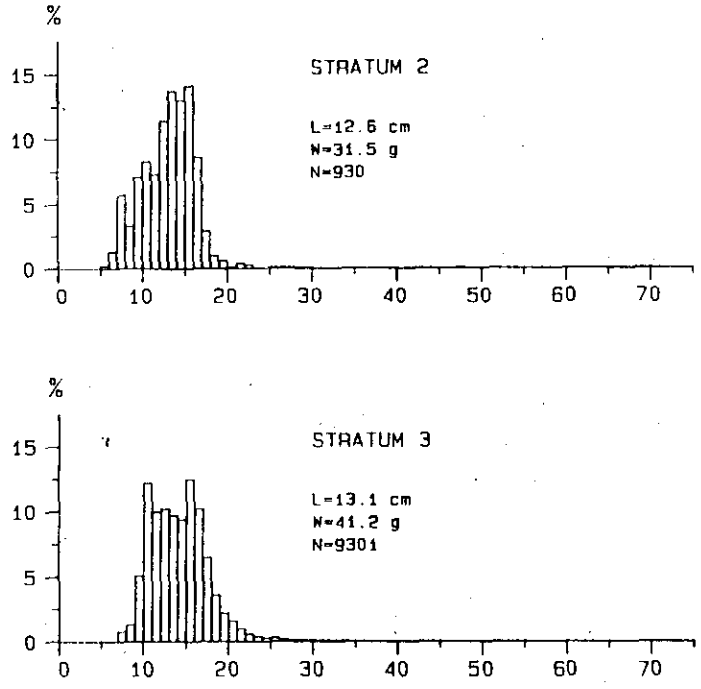

Fig. 3. Length distribution of redfish from "Sisimiut"'s trawlings in 1976-77 (L: mean length, W: mean weight, N: number of fish).

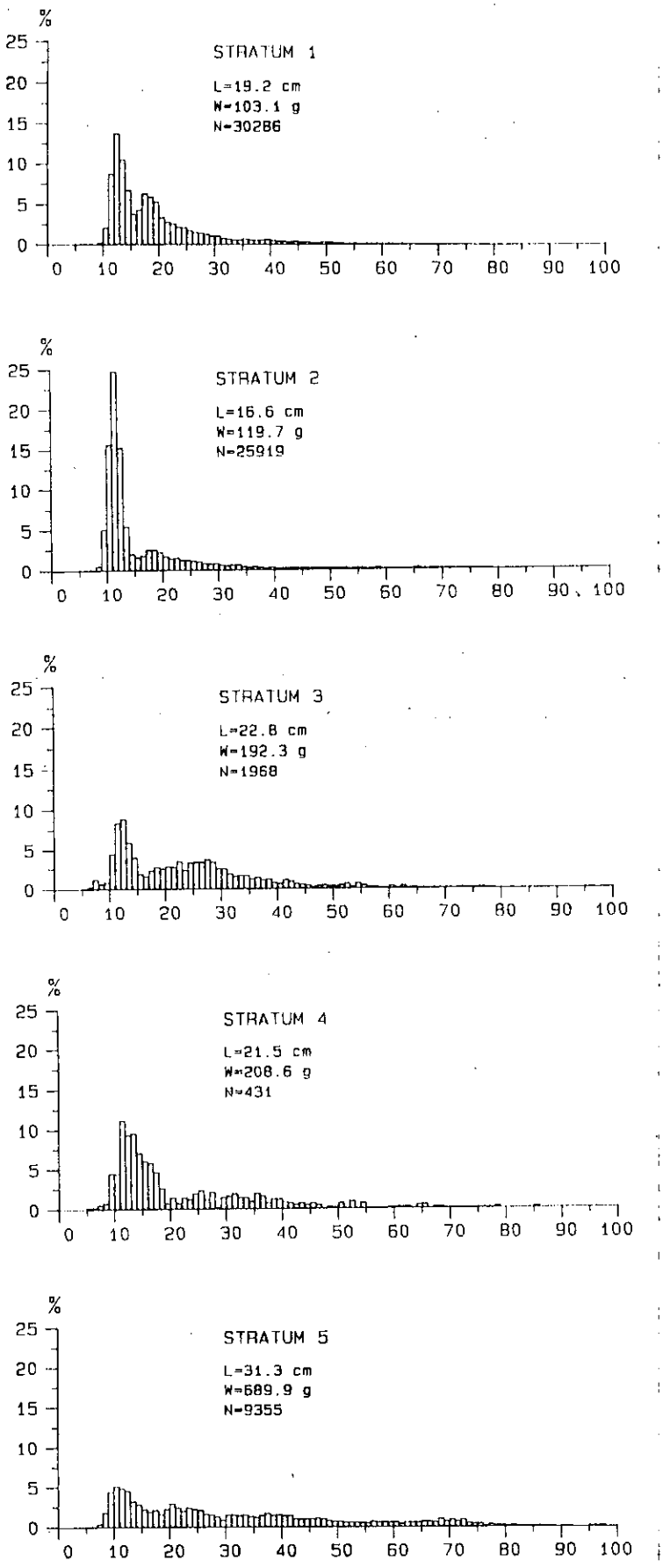

Fig. 4. Length distribution of Greenland halibut from "Adolf Jensen"'s trawl surveys in 1968-87 (L: mean length, W: mean weight, N: number of fish).

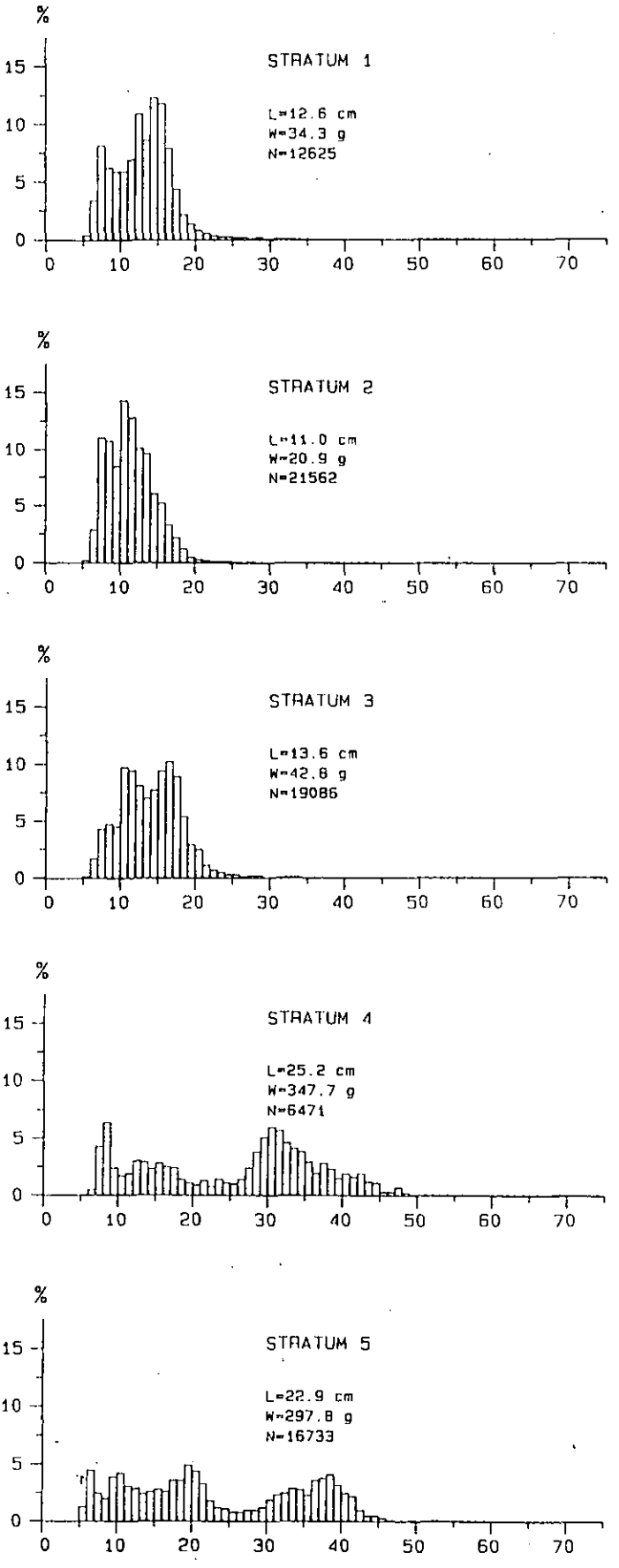

Fig. 5. Length distribution of redfish "Adolf Jensen"'s trawl surveys in 1968-87 (L: mean length, W: mean weight, N: number of fish).